Evidence that Synchronized Motor Unit Firings Are Epiphenomena of the Onion Skin Property Not Common Inputs

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Motivation

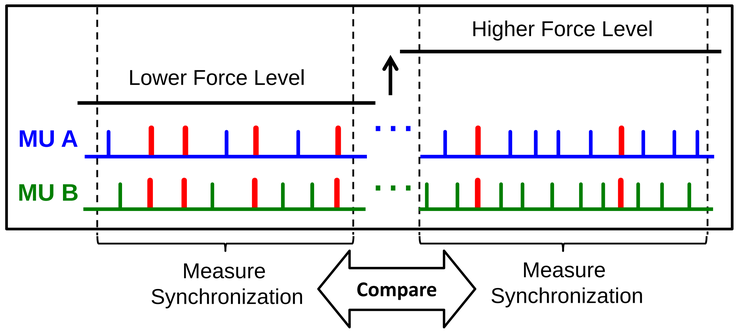
Synchronous motor unit (MU) firing instances have been attributed to anatomical inputs shared by motoneurons. Yet, there is a lack of empirical evidence confirming the notion that common inputs are responsible fro synchronization during voluntary conditions. Therefore, we designed two experiments to:

1) test the veracity of the common input notion; and
2) investigate alternative empirically-based explanations for synchronization.

Experiment

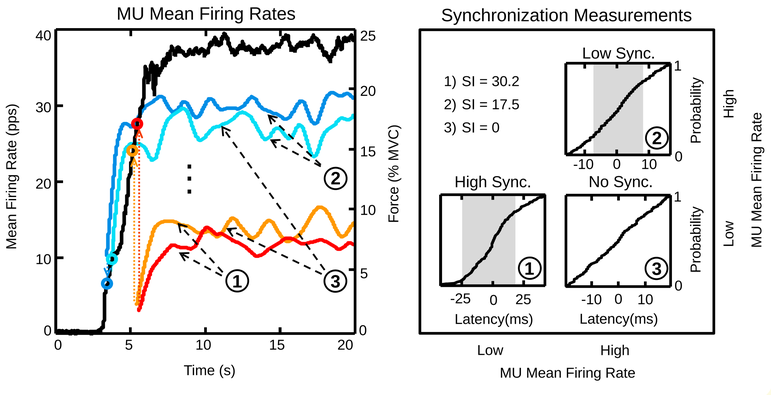
Experiment 1: Testing the Common Input Notion

Subjects were required to track a two-force level paradigm that was maintained at a relatively low force level and then increased to a relatively higher force level. We used the dEMG System for decomposing sEMG signals into MU action potential trains (MUAPTs) and compared the degree of synchronization measured by the SigMax method (De Luca and Kline, 2014) between MUAPTs as their firing rates progressed throughout the increasing force contraction.



Experiment 2: Investigating Empirical Relationships with Synchronization

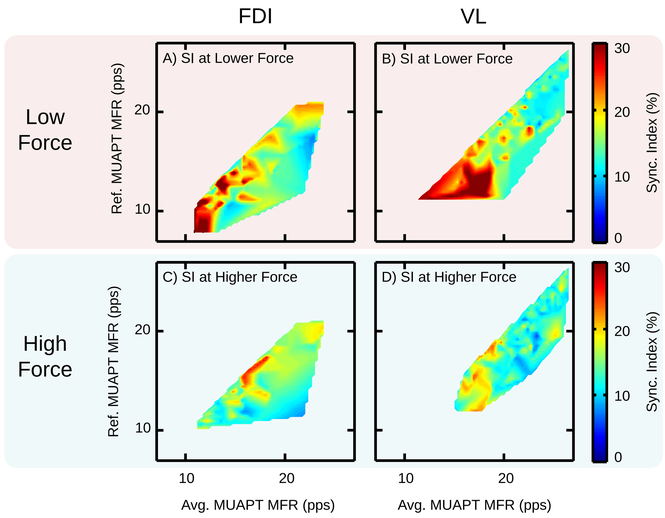
We studied associations between synchronization and MU firing rates in different muscles and for different voluntary contraction force levels by measuring the synchronization index (SI) between pairs of MUAPTs active during voluntary contractions ranging from 5% MVC to 50% MVC in the first dorsal interosseous (FDI) and vastus lateralis (VL) muscles.



Experiment 1: Testing The Common Input Notion

Synchronization Decreases with Increasing Force

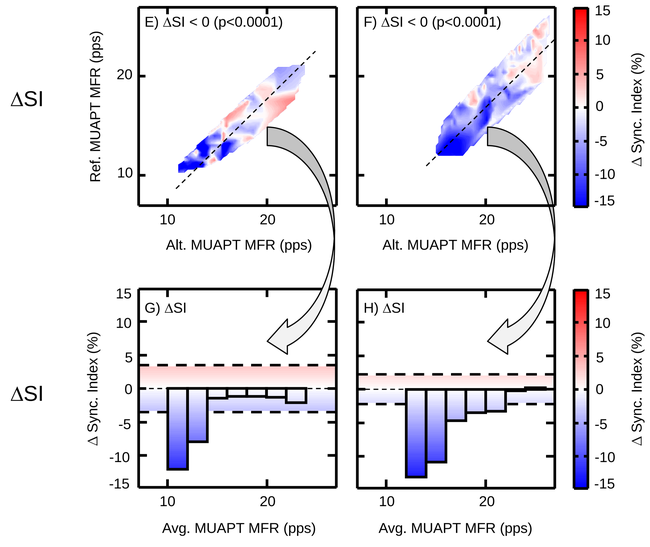
We measured synchronization between the same pairs of MUAPTs as their firing rates progressed from a contraction at a relatively low force level to a higher one. As the contraction force increased, synchronization decreased.



"Common Input" Provides no Explanation

The common input notion provides no empirically supported explanation to account for the decrease in synchronization with increasing contraction force.

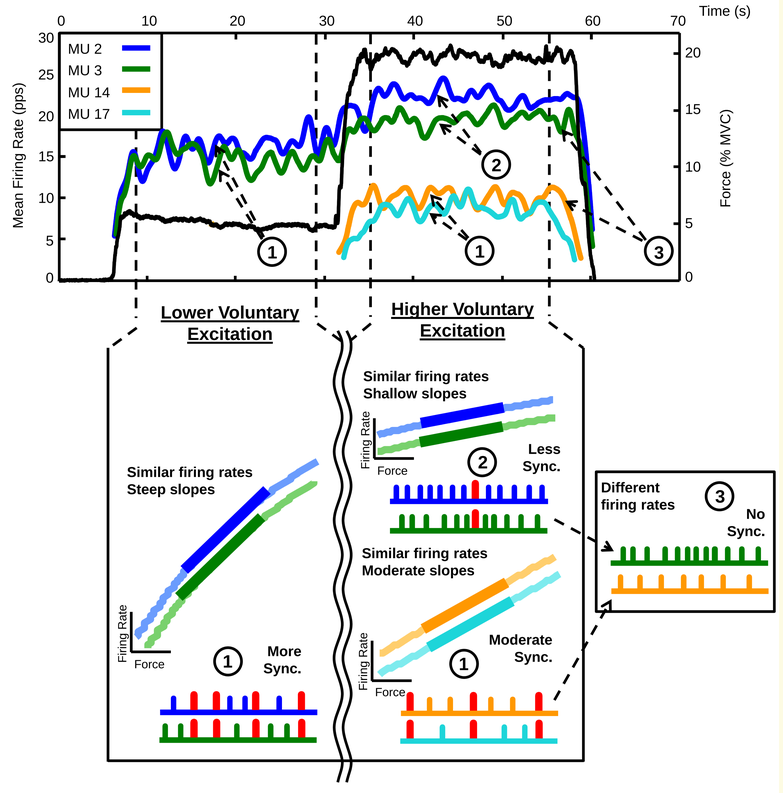
Thus, the practice of inferring anatomical connections shared by motoneurons based on observations of synchronization remains empirically unsupported.



Experiment 2: New Explanation for Synchronization

Synchronization is Related to the Characteristics of the Motor Unit Firing Rates

Our data set of 17,546 paired MUAPTs revealed that the degree of synchronization varies as a function of two characteristics of the firing rate: the slope and similarity of the firing rates. Both are measures of the excitation of the motoneurons (De Luca and Contessa, 2012). As the force generated by the muscle increases the firing rate slope decreases and the synchronization correspondingly decreases. Different muscles have motor units with different firing rate characteristics, and display different amounts of synchronization.



So viewed, occasionally synchronous firing instances are likely an epiphenomenon, subject to countless unknown neural interactions. As such, synchronization may not be the product of a specific design and may not serve a specific physiological purpose.

Our explanation for synchronization has the advantage of being supported by empirical evidence; whereas, the common input does not.

References

De Luca et al, *J Neurophysiol* (1993)
De Luca and Contessa, *J Neurophysiol* (2012)
De Luca and Kline, *J Neurophysiol* (2014)

Acknowledgements

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